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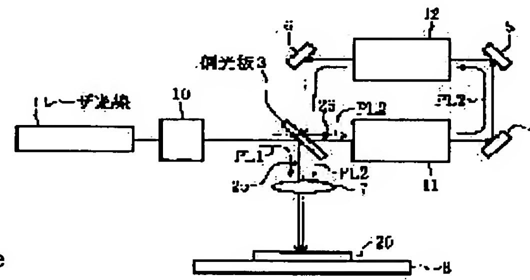
(54) LASER BEAM MACHINE AND MACHINING METHOD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a laser beam machine capable of flexibly changing characteristics of a pulse laser beam according to the quality of a material and structure of a machining object and a shape of a hold to be machined.
SOLUTION: A pulse laser beam which is emitted from a laser beam source 1 is branched off to the first beam propagating along the first optical axis 25 and the second beam propagating along the second optical axis 26 by the first optical element 10. The second optical element 11 which changes optical characteristics of the second beam is arranged inside of an optical path of the second beam. The second beam 26 and the first beam 25 which are changed their optical characteristics by the second optical element 11 is propagated by the third optical element 12 along the same optical axis. A machining object 20 is held on a stage 8. The first and the second beams are condensed on the machining object 20 along the same optical axis.

レーザ加工装置



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CLAIMS

[Claim(s)]
[Claim 1] The 1st optical element which branches the laser light source which carries out outgoing radiation of the pulse laser beam, and the 1st beam which spreads at least the pulse laser beam which carried out outgoing radiation from said laser light source in accordance with the 1st optical axis and the 2nd beam spread in accordance with the 2nd optical axis, The 2nd optical element to which it is arranged in the optical path of said 2nd beam, and the optical property of this 2nd beam is changed, The 2nd beam changed by said 2nd optical element in the optical property, The 3rd optical element which changes the travelling direction of said the 1st or 2nd beam so that said 1st beam may spread in accordance with the same optical axis, Laser-beam-machining equipment which has the 4th optical element which condenses the stage holding a processing object, and said 1st and 2nd beams spread in accordance with the same optical axis on the processing object held on said stage.
[Claim 2] Laser-beam-machining equipment according to claim 1 with which said 2nd optical element delays said 2nd beam.
[Claim 3] Laser-beam-machining equipment according to claim 1 with which said 2nd optical element makes reverse the inclination of the power density distribution about radial [in a beam cross section].
[Claim 4] Laser-beam-machining equipment according to claim 3 with which said 2nd optical element delays said 2nd beam further..
[Claim 5] Laser-beam-machining equipment according to claim 1 with which said 2nd optical element shortens pulse width of said 2nd beam, and delays it.
[Claim 6] Laser-beam-machining equipment according to claim 5 with which this 2nd beam is delayed so that the 2nd beam by which said 2nd optical element was formed into the short pulse may lap with the falling part of the pulse of said 1st beam.
[Claim 7] Furthermore, laser-beam-machining equipment according to claim 5 or 6 with which it has the chirp component which gives a frequency chirp to the pulse laser beam which carried out outgoing radiation from said laser light source, and said 2nd optical element contains a chirp compensation component.
[Claim 8] Laser-beam-machining equipment according to claim 1 which distributes the pulse laser beam in which said 1st optical system carried out outgoing radiation from said laser light source to said the 1st beam and 2nd beam per pulse.
[Claim 9] The laser-beam-machining approach of having the process which generates the pulse laser beam which time amount until it reaches peak power from the standup of a pulse falls after reaching peak power, and has the shape of a pulse form longer than the time amount to completion, and the process which irradiates said pulse laser beam on the front face of a processing object, and performs a perforating process.
[Claim 10] The laser-beam-machining approach of having the process which generates the pulse laser beam in the time of day which becomes one half of the power of peak power in which it starts and the absolute value of the inclination of a part has the shape of a pulse form smaller than the absolute value of the inclination of a falling part, and the process which irradiates said pulse laser beam on the front face of a processing object, and performs a perforating process.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the processing equipment and the processing approach of irradiating a pulse laser beam and carrying out a perforating process to a processing object about laser-beam-machining equipment and the processing approach.
[0002]
[Description of the Prior Art] In the conventional laser beam machining, processing was performed by condensing the pulse laser beam by which outgoing radiation was carried out from the laser light source at one processing point. The pulse shape of a pulse laser beam was mostly decided by the laser light source. For this reason, it was difficult to change pulse shape flexibly with the quality of the material of a processing object, or the configuration of a hole which should be processed. Moreover, it was difficult to process it with a processing object by changing flexibly the power density distribution in wavelength, pulse separation, and a beam cross section etc.
[0003]
[Problem(s) to be Solved by the Invention] The purpose of this invention is offering the laser-beam-machining equipment which can change the property of a pulse laser beam flexibly according to the quality of the material and structure of a processing object, and the configuration of the hole which should be processed.
[0004] Other purposes of this invention are offering the laser-beam-machining approach which can prevent turbulence of the configuration of the hole by melting of a processing object etc.
[0005]
[Means for Solving the Problem] The laser light source which carries out outgoing radiation of the pulse laser beam according to one viewpoint of this invention, The 1st optical element which branches the 1st beam which spreads at least the pulse laser beam which carried out outgoing radiation in accordance with the 1st optical axis from said laser light source, and the 2nd beam spread in accordance with the 2nd optical axis, The 2nd optical element to which it is arranged in the optical path of said 2nd beam, and the optical property of this 2nd beam is changed, The 2nd beam changed by said 2nd optical element in the optical property, The 3rd optical element which changes the travelling direction of said the 1st or 2nd beam so that said 1st beam may spread in accordance with the same optical axis, The laser-beam-machining equipment which has the 4th optical element which condenses the stage holding a processing object and said 1st and 2nd beams spread in accordance with the same optical axis on the processing object held on said stage is offered.
[0006] Since the 2nd beam from which an optical property differs is condensed on a processing object in accordance with the same optical axis, the 1st beam and it are processible with the beam which has the pulse shape suitable for processing etc.
[0007] The laser-beam-machining approach of having the process which generates the pulse laser beam which according to other viewpoints of this invention time amount until it reaches peak power from the standup of a pulse falls after reaching peak power, and has the shape of a pulse form longer than the time amount to completion, and the process which irradiates said

pulse laser beam on the front face of a processing object, and performs a perforating process is offered.
[0008] According to the viewpoint of further others of this invention, the laser-beam-machining approach of having the process which generates the pulse laser beam in the time of day which becomes one half of the power of peak power in which it starts and the absolute value of the inclination of a part has the shape of a pulse form smaller than the absolute value of the inclination of a falling part, and the process which irradiates said pulse laser beam on the front face of a processing object, and performs a perforating process is offered.
[0009] Since falling of pulse shape is steep, after a hole opens, it can prevent that the ingredient around a hole fuses. Thereby, the hole of a desired configuration can be made.
[0010]
[Embodiment of the Invention] The schematic diagram of the laser-beam-machining equipment by the example of this invention is shown in drawing 1 . A laser light source 1 carries out outgoing radiation of the pulse laser beam. A laser light source 1 consists of CO_2 gas laser, an YAG laser, YLF laser, YVO_4 laser, excimer laser, Ti:sapphire laser, semiconductor laser, or an Ar ion laser. The pulse laser beam which carried out outgoing radiation from the laser light source 1 carries out incidence to the 1st field of a polarizing plate 3 at 45 degrees of incident angles. S component (component which polarized in the perpendicular direction to plane of incidence) of a pulse laser beam reflects with a polarizing plate 3, and serves as the 1st beam PL 1 spread in accordance with an optical axis 25. P component (component which polarized in the direction parallel to plane of incidence) of a pulse laser beam penetrates a polarizing plate 3, and serves as the 2nd beam PL 2 spread in accordance with an optical axis 26. When the energy of S component of a pulse laser beam and P component which carry out incidence to a polarizing plate 3 is equal, the energy per one pulse of the 1st beam PL 1 and the 2nd beam PL 2 becomes equal.
[0011] In the optical path of the pulse laser beam between a laser light source 1 and a polarizing plate 3, an optical element 10 is arranged if needed. When the energy of S component of a pulse laser beam and P component is not equal, both energy can be made equal by arranging Faraday rotator in the location of an optical element 10. In addition, the optical element to which the polarization direction can be changed, for example, 1/2 wavelength plate, a quarter-wave length plate, etc. can also be used out of Faraday rotator. In the example explained below, the energy of S component and P component considers as an equal.
[0012] It is reflected by the reflective mirrors 4, 5, and 6, and re-incidence of the 2nd beam PL 2 spread in accordance with an optical axis 26 is carried out to the 2nd field of a polarizing plate 3 at 45 degrees of incident angles. Since the 2nd beam PL 2 contains only P component to a polarizing plate 3, it penetrates a polarizing plate 3 and spreads it in accordance with the same optical axis 25 as the 1st beam PL 1. If needed, an optical element 11 is arranged in the optical path between a polarizing plate 3 and the reflective mirror 4, and an optical element 12 is arranged in the optical path between the reflective mirrors 5 and 6. In addition, other optical elements may be arranged in the optical path between the reflective mirrors 4 and 5 or between the reflective mirror 6 and a polarizing plate 3.
[0013] A stage 8 holds the processing object 20 on the top face. The condensing optical element 7, for example, a convex lens, condenses the 1st beam PL 1 spread in accordance with the 1st optical axis 25, and the 2nd beam PL 2 on the front face of the processing object 20.
[0014] Optical elements 11 and 12 change the optical property of the 2nd beam PL 2. For example, perform wavelength conversion, change pulse shape, the power density distribution in a beam cross section is changed, or delay is produced. Since the 1st beam PL 1 and the 2nd beam PL 2 from which the optical property changed will be irradiated by the front face of the processing object 20, compared with the case where the optical property of one pulse laser beam is changed, it becomes possible to change the property of a pulse laser beam more flexibly.

[0015] Moreover, if a Faraday-rotation component etc. is arranged and the polarization direction is shifted in the optical path of the 2nd beam PL 2, it will be reflected with a polarizing plate 3 and some components of the 2nd beam PL 2 will carry out re-incidence to an optical element

11. While a beam goes around the inside of the circumference optical path demarcated by the polarizing plate 3 and the reflective mirrors 4, 5, and 6 by this, it is introduced little by little into the processing object 20.
[0016] Next, the 1st example of the above-mentioned example is explained with reference to drawing 2 . By the 1st example, an axicon telescope is used as an optical element 12, using a delay element, for example, an optical fiber, as an optical element 11.
[0017] Drawing 2 (A) shows the power density distribution in the beam cross section of the 1st beam PL 1. Generally, power density distribution can be approximated by Gaussian distribution. Drawing 2 (B) shows power density distribution of the 2nd beam PL 2 after passing an optical element 11. By passing an axicon telescope, it is possible to consider as the distribution in which the center became depressed. That is, the inclination of the power density distribution about radial [of the 2nd beam PL 2] becomes it of the 1st beam PL 1, and reverse. In order that an optical element 12 may delay the 2nd beam PL 2, the 1st beam PL 1 reaches the processing object 20 first, and the 2nd beam PL 2 reaches after that.
[0018] Drawing 2 (C) shows the cross-section configuration of the hole formed of the exposure of the 1st beam PL 1. Since power density distribution of the 1st beam PL 1 is approximated to Gaussian distribution, the hole of a U character mold with a deep core is formed. Drawing 2 (D) shows the cross-section configuration of the hole after the 2nd beam PL 2 was irradiated. The side face of a hole is deleted by the 2nd beam PL 2, and the hole of the cross-section configuration where the side face rose steeply is obtained.
[0019] In the 1st example of the above, although the case where an axicon telescope was used as an optical element 11 was explained, instead of an axicon telescope, the power density of the core of a beam may be reduced and other optical elements which can raise the power density of a periphery may be used. An aspheric lens etc. is mentioned as such an optical element.
[0020] Next, the 2nd example of the above-mentioned example is explained with reference to drawing 3 . By the 2nd example, the component which makes the location of an optical element 10 produce a frequency chirp is arranged, the component which performs chirp compensation in the location of an optical element 11 is arranged, and a delay element is arranged in the location of an optical element 12. As a component which produces a frequency chirp, an optical fiber with for example, the self-phase modulation effectiveness can be used. For example, a grating pair can be used as a component which performs chirp compensation.
[0021] Drawing 3 (A) shows the pulse shape of both in case the 1st beam PL 1 and the 2nd beam PL 2 do not lap on a time-axis on an optical axis 25. Since the 1st beam PL 1 has received the frequency chirp, it has comparatively long pulse width. Since chirp compensation is carried out, the 2nd beam PL 2 has comparatively short pulse width.
[0022] When the 1st beam PL 1 is irradiated by the processing object 20, the point of the processing object 20 irradiating [beam] is heated. Since peak power is low, a hole is not formed or a shallow hole is formed. Before the irradiating point of the 1st beam PL 1 is cooled, the 2nd beam PL 2 is irradiated. A deep hole is formed in the irradiating point of the exposure of the 2nd beam PL 2.
[0023] It is considered to be based on the thermal effectiveness of laser that perforation is performed by the laser radiation of an infrared region. That is, if laser radiation is performed, it will fuse and evaporate near the irradiating point of a processing object. Since the 2nd beam PL 2 is irradiated before the location which should perforate is cooled, a hole opens comparatively easily. If the laser beam of sufficient power to carry out melting of the processing object is irradiated even after a hole is formed, a melting layer is formed on the side attachment wall of a hole, and in order to solidify without removing it, it will lead to deterioration of processing quality. For this reason, it becomes difficult about a desired configuration to form a hole. The 2nd beam PL 2 shown in drawing 3 (A) is formed into the short pulse, and its falling of the pulse shape is steep. For this reason, after a hole is formed, it can prevent that the ingredient around a hole fuses and the hole of a desired configuration can be formed.
[0024] Drawing 3 (B) shows pulse shape when the 2nd beam PL 2 laps with the falling part of the 1st pulse PL 1. The pulse with which both lapped has pulse shape with which time amount until it reaches peak power from the standup falls after reaching peak power, and it becomes longer

than the time amount to co[illegible]ion. Or it has pulse shape in the time[illegible]ay which becomes one half of the power of peak power with which it starts and the absolute value of the inclination of a part becomes smaller than the absolute value of the inclination of a falling part. Also in the pulse shape shown in drawing 3 (B), since the falling is steep, the hole of a desired configuration can be formed.

[0025] Other combination is considered by these arrangement, although the chirp component is arranged in the location of an optical element 10, the chirp compensation component is arranged in the location of an optical element 11 and the delay element has been arranged in the location of an optical element 12 by the above-mentioned example. For example, a chirp component may be arranged in the location of an optical element 11, and a delay element may be arranged in the location of an optical element 12. In this case, while the 2nd beam PL 2 is delayed for the 1st beam PL 1, the pulse width of the 2nd beam PL 2 becomes shorter than the pulse width of the 1st beam PL 1. In addition, if a chirp compensation component is further arranged after the chirp component arranged in the location of an optical element 11, the 2nd beam PL 2 can be made into a short pulse from the 1st beam PL 1. If an optical fiber is used as a chirp component, a chirp component can be made to serve as a delay element.

[0026] Next, other examples are explained. If delay elements, such as an optical fiber, are arranged in the location of an optical element 11, only a few will shift and the 1st beam PL 1 and the 2nd beam PL 2 will lap with it. Thereby, pulse width can be lengthened. By changing the time delay of the 2nd beam PL 2, the width of face of the pulse superimposed on the 1st beam PL 1 and the 2nd beam PL 2 is changeable. Moreover, if the 2nd beam PL 2 lengthens a time delay to extent which does not lap with the 1st beam PL 1, two pulses can form the pulse train located in a line on the time-axis.

[0027] If a zoom lens is arranged in the location of an optical element 11, the spot size of the 2nd beam PL 2 on the front face of the processing object 20 is changeable. If the 1st beam PL 1 and the 2nd beam PL 2 are irradiated in piles, Susono of power density distribution of the beam spot will become gently-sloping. If the 2nd beam PL 2 is delayed, laser radiation can be first carried out laser radiation and performed to a larger field to a small field with low power density continuously by the high-power consistency. On the contrary, it is also possible to carry out laser radiation and perform laser radiation to a small field to a large field by the high-power consistency continuously with low power density first.

[0028] When a wavelength sensing element is arranged in the location of an optical element 11, the wavelength of the 2nd beam PL 2 and the wavelength of the 1st beam PL 1 can be changed. An optical parametric oscillator can be used as a wavelength sensing element. Thereby, the pulse laser beam containing the component of two wavelength can be irradiated at coincidence. The wavelength suitable for processing changes with ingredients. By irradiating the pulse laser beam containing the component of two wavelength at coincidence, and performing a perforating process, the configuration of a hole may be able to be brought close to a desired configuration.

[0029] If a laser amplifier is arranged in the location of an optical element 11 and a delay element is arranged in the location of an optical element 12, the 2nd high-power beam PL 2 can be continuously irradiated the 1st beam PL 1 and irradiated to the processing object 20.

[0030] If the combination of electro-optics components, such as a POKKERUSU component, and a polarizing plate or an acoustooptics component is arranged in the location of an optical element 11, only a specific part can be started from the time amount wave of the 2nd beam PL 2.

[0031] If the image relay optical system and the beam expander containing a mask are arranged in the location of an optical element 11, while enlarging a beam diameter, the skirt length part of the power density distribution in a beam cross section (beam profile) can be cut off. This combination is suitable for punching processing to the resin substrate by which coating was carried out by the metal membrane etc. For example, punching can be performed to a metal membrane with the 1st beam PL 1 of a short pulse, and punching can be performed to a resin substrate with the 2nd broadcloth beam. Since the beam profile of the 2nd broadcloth pulse is operated orthopedically, high processing quality can be acquired.

[0032] In the above-mentioned example, although the energy per one pulse of the 1st beam PL 1

and the 2nd beam PL 2 con[illegible]ed as the equal, the energy per one p[illegible] of both may be changed. If Faraday rotator, 1/2 wavelength plate, or a quarter-wave length plate is arranged in the location of an optical element 10 and the polarization direction is controlled, the rate of energy partitioning by the polarizing plate 3 is controllable. Furthermore, if a delay element is arranged in the location of an optical element 11, two pulses from which the energy per one pulse differs can be irradiated with a predetermined time interval at the processing object 20.
[0033] Moreover, if an electro-optics component is arranged in the location of an optical element 10 and the polarization direction is changed by time amount, the rate of energy partitioning by the polarizing plate 3 can be changed in time. For example, the 1st period sets P component to 0, and if S component is set to 0, other 2nd period can irradiate the 1st beam PL 1 at the 1st period, and can irradiate the 2nd beam PL 2 at the 2nd period. That is, a pulse laser beam can be distributed to the 1st beam PL 1 and the 2nd beam PL 2 per pulse. If the 1st period and 2nd period are changed the same period as the repeat period of the pulse of a laser light source 1, the exposure of the 1st beam PL 1 and the exposure of the 2nd beam PL 2 can be performed by turns.
[0034] Although this invention was explained in accordance with the example above, this invention is not restricted to these. For example, probably, it will be obvious to this contractor for various modification, amelioration, combination, etc. to be possible.
[0035]
[Effect of the Invention] As explained above, according to this invention, a pulse laser beam can be divided into two beams, and the optical property of one beam can be changed. After changing the optical property of one beam, two beams are made to spread in accordance with the same optical axis, and it irradiates on a processing object. It becomes possible to make into the thing suitable for laser beam machining by this the property of the beam irradiated on a processing object.

[Translation done.]

* NOTICES *

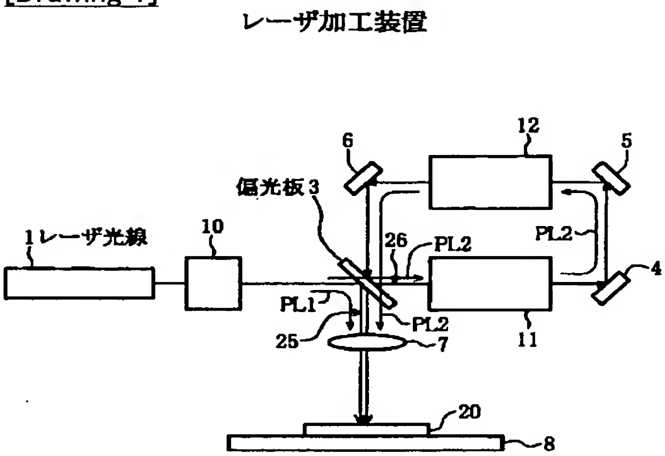
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the schematic diagram of the laser-beam-machining equipment by the example of this invention.
[Drawing 2] They are the sectional view of the graph which shows the power density distribution in the beam cross section of the 1st and 2nd beams used by the approach by the 1st example of the example of this invention, and the hole formed of the 1st beam exposure, and the sectional view of the hole after irradiating the 2nd beam.
[Drawing 3] It is the graph which shows the pulse shape of the 1st and 2nd beams used by the approach by the 2nd example of the example of this invention.
[Description of Notations]
1 Laser Light Source
3 Polarizing Plate
4, 5, 6 Reflective mirror
7 Condensing Optical Element
8 Stage
10, 11, 12 Optical element
20 Processing Object
25 1st Optical Axis
26 2nd Optical Axis

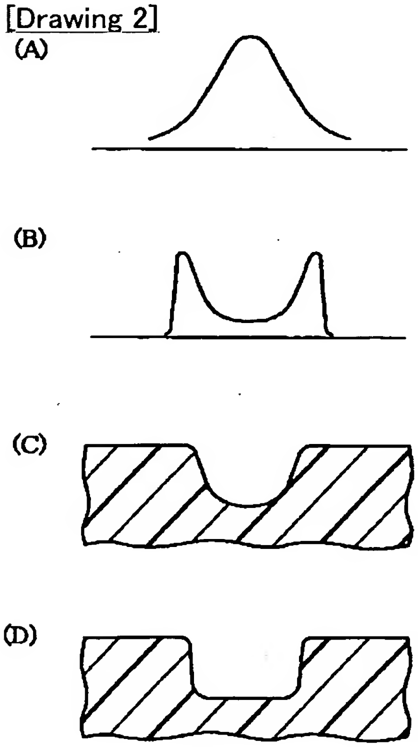
[Translation done.]

DRAWINGS

[Drawing 1]

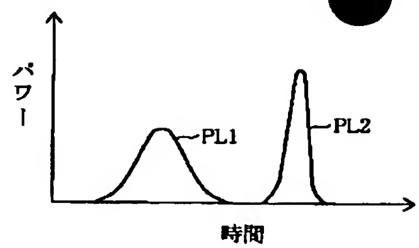


[Drawing 2]



[Drawing 3]

(A)



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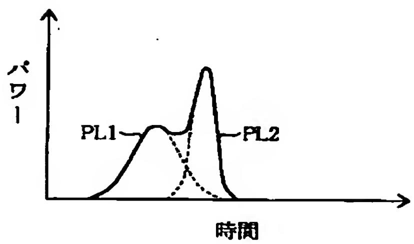

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